Course description

Good scientific data collection involves a protocol that specifies where (i.e., spatial locations) and when (i.e., temporal instants) measurements are taken. Scientists want to answer "why" questions, and often space and time play critical roles. This short course offers a practical, hands-on, introduction to spatio-temporal statistical modelling, with case studies drawn from the environmental and ecological sciences.

This two day course considers a systematic approach to key quantitative techniques for the analysis of spatio-temporal data, with a particular emphasis on hierarchical (empirical and Bayesian) statistical modelling. The course will cover the following topics in spatio-temporal modelling

- Key concepts of hierarchical modelling; overview of requisite background in spatial statistics.
- Data wrangling with spatio-temporal data.
- Spatio-temporal data classes in *R*.
- Visualisation of spatio-temporal data using lattices and grammar of graphics.
- Exploratory techniques for spatio-temporal data (including visualisation and empirical dimension-reduction).
- Standard statistical models for spatio-temporal data.
- Covariance functions and spatio-temporal kriging in practice.
- Rank-reduced spatio-temporal modelling approaches.
- Non-Gaussian spatio-temporal modelling.
- Dynamic spatio-temporal modelling.

A sizeable portion of the workshop is hands-on. Participants are required to bring their own laptop with R v3.3 or higher installed. The workshops will make direct use of the following R packages which should also be installed from CRAN using *install.packages* prior to the workshop:

animation, ape, broom, CCA, dplyr, fields, FRK, ggplot2, gstat, lattice, leaps, lmtest, mgcv, nlme, purrr, RColorBrewer, sp, spacetime, SpatioTemporal.

The participants will also need *INLA, STRbook* and *IDE*. For the former visit http://www.r-inla.org/download and follow the instructions. For the latter two first install *devtools*, then type

```
library(devtools)
install_github('andrewzm/STRbook')
install_github('andrewzm/IDE')
```

Participants will receive a printed copy of the slides used in the presentations as well as a printed copy of the "Labs" for conducting the computer-lab sessions.

Target Audience

This course is aimed at researchers and students with a basic understanding of R, and a Bachelor-to-postgraduate level understanding of probability, statistical inference, and matrix algebra.

Instructor

Andrew Zammit Mangion is Senior Lecturer with the National Institute for Applied Statistics Research Australia (NIASRA) at the University of Wollongong, Australia. He obtained his PhD

from the University of Sheffield, UK on spatio-temporal modelling, and has also held postdoctoral fellow appointments at the University of Edinburgh, UK and the University of Bristol, UK. He has applied his work on spatio-temporal modelling in several contexts within the social and environmental sciences. In 2013 Andrew was awarded a National Academy of Sciences of the USA prize for his work on the modelling and prediction of armed conflicts. Andrew has authored and co-authored over 20 articles in the field of spatial and spatio-temporal statistics, most of them using remote-sensing data, and is the author of two R packages on CRAN, Enhanced False Discovery Rate (*EFDR*), and Fixed Rank Kriging (*FRK*). In 2017 he was a recipient of a Discovery Early Career Research Award (DECRA) fellowship.

Timetable

Day 1

09:00 Lecture 1: Introduction to spatio-temporal modelling
09:30 Lecture 2.1: Data wrangling and visualization of spatio-temporal data
10:15 Break
10:30 Lab 2.1: Data wrangling of spatio-temporal data
11:00 Lab 2.2: Visualization of spatio-temporal data
11:30 Lecture 2.2: Exploratory analysis of spatio-temporal data
12:15 Lunch
13:15 Lab 2.3: Exploratory analysis of spatio-temporal data
13:45 Lecture 3.1: Introduction to modelling of spatio-temporal data
14:30 Lab 3.1: Deterministic prediction methods
15:00 Tea break
15:30 Lab 3.2: Spatio-temporal trend prediction using basis functions
16:15 Lecture 4.1 Descriptive spatio-temporal modelling Part 1
17:15 Close

Day 2

08:30 Lab 4.1: Spatio-temporal kriging using *gstat*
09:00 Lecture 4.2: Descriptive spatio-temporal modelling Part 2
10:00 Break
10:30 Lab 4.2: Fixed-rank kriging using *FRK*
11:00 Lab 4.3: Spatio-temporal generalised additive models *using mgcv*
11:30 Lecture 5.1: Dynamical spatio-temporal modelling Part 1
12:15 Lunch
13:15 Lecture 5.2: Dynamical spatio-temporal modelling Part 2
14:15 Lab 5.2: Spatio-temporal dynamic modelling with *IDE*
14:45 Tea break
15:15 Lecture 5.3: Bayesian inference with spatio-temporal models
15:45 Lab 5.3: Non-Gaussian dynamic spatio-temporal modelling with *INLA*
16:15 Conclusion
16:30 Close